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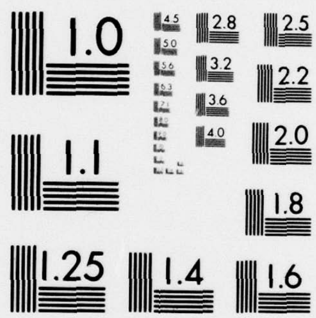

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BOSTON ABSTRACTS

Papers for the Boston Meeting

of the American Physical Society

Division of Plasma Physics

November 12 - 16, 1979

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Papers Presented at the

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Boston, Massachusetts

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This report contains abstracts of the 47 invited and contributed papers to be presented by the UCLA Plasma Physics Group at the APS Plasma Physics Division Annual Meeting, November 12 - 16, 1979, at Boston, Massachusetts. It represents a kind of "snap shot" of work in progress or recently completed as of August, 1979.

INVITED PAPER

1. Probe Measurements of Fluctuations in the UCLA Tokamaks

CONTRIBUTED PAPERS

A. WAVES, INSTABILITIES, AND FLUCTUATIONS

2. Injection of a Non-neutral Electron Beam Into a Bounded Plasma Slab
3. Resonantly Enhanced Electric Fields in a Two-Dimensional Caviton.
4. Recursion of Langmuir Wavepacket.
5. Simulations of Relativistic Waves.
6. Generation of Electromagnetic Radiation in an Inhomogeneous Plasma
7. Wave Excitation and Collisionless Absorption in Bounded Nonuniform Plasmas.
8. On the Localization of Drift Waves in Slab Geometry.
9. The Onset of Finite-Bandwith Induced Stochasticity in Mirrors.
10. Thermal Electric Effects in a Magnetized Plasma.

B. EQUILIBRIUM, STABILITY, AND TRANSPORT

11. MHD Stability of High-Beta Closed-Line Systems.
12. 3-D Magnetohydrodynamic Particle Code with the Lax-Wendroff Algorithm Applied to Ballooning Modes.
13. Simulation Study of the Effect of Larmor Radius Upon Diffusion Rate.

C. SUPERTHERMO AND RUNAWAY ELECTRONS

14. Break-of-Symmetry Radiation with Ions.
15. Clamping of Runaway Electrons by Radiation.
16. Relativistic Electron Ring Experiments in Macrotor.

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31. Deflagration Gun Injection and Heating in the Dodecapole Surmac.
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33. ICRF Heating in Macrotor.
34. Charge Exchange Measurements on Macrotor During ICRF Heating.
35. Electron Temperature Measurements on Macrotor with ICRF Heating.
36. Effect of ICRF Heating on Single Particle Confinement in Tokamaks.
37. Computer Simulation of RF Heating with Lower Hybrid Waves.

H. <u>DIAGNOSTICS</u>

38. Thomson Scattering System for the Dodecapole Surmac.
39. Diagnostics and Computer Based Data Acquisition System for the Dodecapole Surmac.
40. Improved Vacuum Photodiode UV Detector Arrays for the UCLA Tokamaks.

I. <u>FREE ELECTRON LASER</u>

41. Nonlinear Saturation and Thermal Effects on the Free Electron Laser Using an Electromagnetic Pump.
42. Finite-Length Particle Simulations of a Free Electron Laser.

J. <u>IONOSPHERIC AND MAGNETOSPHERIC PLASMA PHYSICS</u>

43. Active Stimulation of the Auroral Plasma.
44. Linear Theory of Tearing in a High-β_e Plasma.
45. Global Simulation of the Magnetosphere in Three-Dimensions.
46. Cold Electrons Heating by Magnetospheric Electrostatic Waves.

K. <u>IMPURITY CONTROL IN TOKAMAKS</u>

47. Experimental Study of In-Situ Wall Coatings in Tokamaks.

1. **Probe Measurements of Fluctuations in the UCLA Tokamaks***

S. J. Zweben, University of California, Los Angeles. (30 min.)

Simple probe techniques have been used to measure magnetic and electrostatic fluctuations in the Macrotor (minor radius a = 45 cm) and Microtor (a = 10 cm) tokamaks at UCLA. Magnetic pickup loops inserted directly into the low power density Macrotor plasma have shown a broadband $\tilde{B}_r$ spectrum extending up to $f \sim 100$ kHz superimposed on the usual Mirnov oscillations at $f \lesssim 10$ kHz.[1] The magnitude $\sum |\tilde{B}_r|/B_T \approx 10^{-4}$-$10^{-5}$ (for $f > 30$ kHz) is in the range theoretically predicted to affect electron heat transport through distortion of the magnetic flux surfaces. The high frequency fluctuations have a short autocorrelation time $\tau_A \lesssim 10$ μsec and a small radial correlation length $L_r \lesssim 5$ cm, in contrast with $\tau_A \geq 1$ msec and $L_r \gtrsim 5$ cm for the coherent low frequency mode at $f \lesssim 10$ kHz. We find in general $|\tilde{B}_r| \approx |\tilde{B}_p| >> |\tilde{B}_T|$, with a correlation length $L_r \approx L_p << L_{tor}$. Electrostatic fluctuations measured with Langmuir probes have shown a large $\tilde{n}_{RMS}/n \approx .2$ near the wall and $\lesssim .1$ nearer the center of Macrotor, with most of the fluctuation power below ~ 50 kHz. Above ≈ 10 kHz the spectrum of $\tilde{n}$ is similar to that of $\tilde{B}_r$, while the radial correlation lengths of $\tilde{n}$ appear to be somewhat smaller than those of $\tilde{B}_r$. The similarity of the $\tilde{B}_r$ and $\tilde{n}$ spectra suggests that they have a common origin; however, the cross-correlation of $\tilde{B}_r$ and $\tilde{n}$ at a point is not high, and the radial profile of $\tilde{B}_r$ is not similar to that of $\tilde{n}$, suggesting that their detailed structures are different. Probe measurements in Microtor also show a broadband spectrum of $\tilde{B}_r$ above the usual low frequency mode at $f \sim 30$ kHz; again $\tilde{n}_{RMS}/n \gtrsim .1$, but for Microtor there is a relatively large $|\tilde{n}|/|\tilde{B}_r|$ for $f \lesssim 30$ kHz. The scaling of these fluctuations with n, I, and B is being investigated to asses their influence on transport.

* Supported by USDOE Contract EY-76-C-03-0010 PA 26

[1] S. J. Zweben, C. R. Menyuk, and R. J. Taylor, Phys. Rev. Lett., 42. 19 (1979).

2. **Injection of a Non-neutral Electron Beam Into a Bounded Plasma Slab.*** W. MAASJOST, G. J. MORALES, V. K. DECYK, UCLA.--A one-dimensional bounded electrostatic particle simulation code is used to study the strong nonlinear interactions that arise during the injection of a non-neutral cold electron beam ($v_b > 5\bar{v}_e$) of high density ($n_b/n_o \sim 0.1$) into a plasma. Self consistent quasi-neutralization is attained by the expulsion of background electrons out of the plasma. Large spatially localized electric fields ($E^2/4\pi n_o T \sim 2$) appear near the injection boundary and act as a gate which periodically chops the beam. Strongly focused charge bunches are generated and move slowly ($v \sim 3\bar{v}_e$) toward the plasma interior. The localized fields are nearly standing waves which exhibit relaxation oscillations and arise due to ambipolar effects on the beam instability. The role of ion inertia and density gradients is also investigated.

*Work supported by O.N.R. and N.S.F.

3. Resonantly Enhanced Electric Fields in a Two-Dimensional Caviton.* D. L. Eggleston, C. B. Darrow, A. Y. Wong, UCLA.--Our earlier[1] experimental investigations of RF-plasma interactions in a plasma-filled coaxial line have been extended to include a detailed study of resonantly enhanced electric fields for the unmagnetized and magnetized ($\omega_{pe}/\omega_{ce} \gtrsim 3$) case as well as the case of an azimuthally non-uniform driver, $\underline{E}_o = \underline{E}_o(r,\theta)$. A non-perturbing 2-D scanning diagnostic electron beam is used to measure the amplitude, direction, and spatial dependence of the enhanced fields near the resonant region ($\omega \approx \omega_{pe}, \omega_{uh}$). The time evolution of these fields is studied using a sampled electron beam technique. Transit time damping of the resonant electric fields by electrons is identified and controlled[2]. The effect of an azimuthally non-uniform driver is studied by splitting the coaxial center conductor and driving the two halves out of phase.

1. D. L. Eggleston and A. Y. Wong, Bull. APS 23, 844 (1978).
2. A. Y. Wong, P. Leung and D. L. Eggleston, Phys. Rev. Lett. 39, 1407 (1977).

*Supported by AFOSR contract F-49620-76-C-0011.

4. Recursion of Langmuir Wavepacket.* M. V. GOLDMAN, U. of Colorado, T. TAJIMA, J. N. LEBOEUF, J. M. DAWSON, UCLA.--Electrostatic particle simulations found that an originally spatially localized Langmuir wavepacket breaks up in space and then comes back roughly into its original packet shape. This recursion time is inversely proportional to the packet energy density, and independent of the system size. One possible explanation is: the density depression created by the wavepacket acts to generate wave spectra with $k \pm nk_o$, where k is the Langmuir wavenumber and k_o is the typical ion depression wavenumber. Such modes are known to recur.[1]

[1]P. K. Kaw, A. T. Lin, J. Dawson, Phys. Fluids 16, 1967 ('73).

*Work supported by N.S.F. and A.F.O.S.R.

5. Simulations of Relativistic Waves.* M. ASHOUR-ABDALLA, J. N. LEBOEUF, T. TAJIMA, C. F. KENNEL, J. M. DAWSON, UCLA.--The interaction of relativistic waves with an electron-positron plasma is of interest for pulsars. 1-2/2 D relativistic electromagnetic simulations have been performed. A spatially localized linearly polarized E.M. wave leads to vacuum creation and acceleration of particles in the x-direction and heating in P_x and P_y. Only for wave frequencies close to the relativistic cutoff $\omega_p/\gamma^{1/2}$ is a substantial modification of the waveform observed. A self-consistent sawtooth input waveform is unstable to short wavelengths perturbations but also leads to pick-up and heating of the particles.

*Work supported by N.A.S.A. and N.S.F.

6. Generation of Electromagnetic Radiation in an Inhomogeneous Plasma.* P. Leung, J. Santoru and A. Y. Wong, UCLA.-- The generation of electromagnetic radiation near the plasma frequency in an inhomogeneous, unmagnetized plasma is investigated. Electron plasma waves are excited by an electron beam (n_b/n_o = 1%, E_b = 25-100 V, I_b = 0.1 - 1.2A). As the electrostatic waves propagate up the density profile, they encounter a region of plasma resonance (ϵ = 0). Measurements of the electromagnetic radiation indicate that this region is the source region. The electromagnetic power spectrum dependence on beam density and energy is discussed. The conversion efficiency (ES to EM) as a function of density gradient scale length is investigated.

*Work supported by NSF PHY77-07160.

7. <u>Wave Excitation and Collisionless Absorption in Bounded Nonuniform Plasmas</u>.* B. LAMB, G. J. MORALES, <u>UCLA</u>.--The integral equation description of the launching and propagation of Langmuir waves in collisionless plasma slabs is solved numerically without recourse to the usual approximate Fourier transform asymptotic techniques, thus enabling the study of a wide variety of problems of physical interest. The simplest problem in this class is the uniform density half-space, which is studied for different types of external exciters and velocity distribution functions. The doubly bounded uniform slab containing multiple particle bounces is considered. The method is also applied to a nonuniform density profile and permits the description of the important process of mode conversion with Landau damping included self-consistently. The effect of nonlinear profile modification due to the ponderomotive force is incorporated. Analytic calculations of power absorption at the surface of RF carrying conductors surrounded by plasmas are presented.

*Work supported by O.N.R. and U.S.D.O.E.

8. <u>On the Localization of Drift Waves in Slab Geometry</u>.* A. BANOS and Y. C. LEE, <u>UCLA</u>.--As part of a continuing investigation[1] of drift waves in thin slabs with Gaussian density profile, $n(x) = n_o \exp(-x^2/L^2)$, we have examined the validity of the assumed localization of drift waves which underlies the conventional theory. We consider a uniform magnetic field along z, and study waves with electrostatic potential $\phi(x)\exp[i(k_y y+k_z z-\omega t)]$. Assuming $\omega/\Omega \ll 1$ and $k_y\rho \ll 1$, where ρ and ω are the ion cyclotron radius and frequency, we convert the integral equation for $\phi(x)$ to a differential equation by expanding in $k_y\rho$ and ρ/L. On solving the resulting eigenvalue problem for $\phi(x)$ and ω, with $k_y\rho = 0.1$, $T_e/T_i=10$, $(k_{De}L)^2=10^3$ and $1 \leq \psi \equiv (k_y/k_z)(m/M)^{1/2} \leq 10$, we find that the unstable solutions are well localized only for $\rho/L \lesssim 0.05$.

*Work supported by U.S.D.O.E. and N.S.F.
[1]Bull. APS <u>23</u>, 826 (1978).

9. <u>The Onset of Finite-Bandwith Induced Stochasticity in Mirrors</u>.* C. R. MENYUK† AND Y. C. LEE, <u>UCLA</u>.--We discuss the role that a finite bandwidth (in the electrostatic fluctuation spectrum) plays in destroying superadiabatic motion in mirrors. Virtually any bandwidth is sufficient to destroy the "island" region about the elliptical fixed points. To destroy all of phase space, so that the ions move freely, requires a bandwidth on the order of the inverse bounce time in the mirror. Assuming such a bandwidth, we calculate the diffusion rate in velocity space.

*Work supported by N.S.F.

†Work additionally supported by Fannie and John Hertz Foundation.

10. Thermal Electric Effects in A Magnetized Plasma.* A. T. LIN, J. M. DAWSON, UCLA.--In recent years the magnetic field fluctuations have been considered as a major mechanism responsible for the anomalous electron energy loss in Tokamak. In a magnetized plasma, ($\nabla T \times \nabla n$) and ∇T with collisions (Nernst effect) could give rise to thermal electric fields and hence magnetic field fluctuations. Using a two and one-half dimensional magnetostatic particle code we have observed the generation of the magnetic field fluctuations and the enhanced electron energy transport across the magnetic field line.

*Work supported by U.S.D.O.E.

11. MHD Stability of High-Beta Closed-Line Systems.* P. L. PRITCHETT, UCLA.--The ideal MHD stability of high-beta model equilibria in slab geometry with $B_z=0$ and containing elongated regions of closed field lines is investigated as an initial-value problem and in terms of the energy principle. For large enough elongation, flute (interchange) modes are found to be stable throughout the closed region. Co-interchange modes with the character of an m=1 kink mode, however, are found to be unstable. The growth rate of these modes initially increases rapidly with k_z and then approaches a finite limit as $k_z \to \infty$. The addition of a small axial field strongly suppresses the instability. The implications of this work for field-reversed theta pinches will be discussed.

*Work supported by U.S.D.O.E. and N.S.F.

12. 3-D Magnetohydrodynamic Particle Code with the Lax-Wendroff Algorithm Applied to Ballooning Modes.* F. BRUNEL†, T. TAJIMA, J. N. LEBOEUF, J. M. DAWSON, UCLA. --A significant improvement of a 3-D particle-MHD code[1] is achieved by converting from the Lax to the Lax-Wendroff method for advancing the magnetic field. Sharper mode spectra are obtained than with the Lax method using the present code, as numerical diffusion of the magnetic fields is reduced to a value of the order of $(k\Delta)^4$. Thanks to the low magnetic diffusion with this algorithm along with the particle nature of the code which satisfies the continuity equation exactly, we are able to handle problems with large density variations and sharp density gradients (even sharp boundaries are acceptable). Applications have been started with the study of ballooning instabilities for a sharp boundary plasma slab that has a bad curvature region connected with a good one: the curvature is simulated by a gravitational force g. Preliminary results are in reasonable agreement with theoretical predictions and will be presented.

[1]J. N. Leboeuf, T. Tajima, and J. M. Dawson, J. Comp. Phys. 31, 379 (1979).
*Work supported by U.S.D.O.E. and N.S.F.
†Supported by D.G.E.S. Fellowship.

13. <u>Simulation Study of The Effect of Larmor Radius Upon Diffusion Rate.</u>* ROBERT W. HUFF, J. M. DAWSON, T. KAMIMURA†, <u>UCLA</u>.--Multi-species simulations were run using the $2\frac{1}{2}$-dimensional electrostatic particle code with fixed magnetic field as implemented on the CHI Computer at UCLA. A range of Larmor radii was obtained by using various masses and temperatures within a given simulation. The diffusion rate was consistently found to be a monotonically decreasing function of Larmor radius. This is attributed to partial cancellation of $E \times B$ drift velocity when averaged over the larger Larmor orbits, whereas the species with smaller orbits can move with the full local $E \times B$ velocity. One consequence of this effect is that heat diffuses slower than particles for a given species.

*Work supported by U.S.D.O.E.
†Nagoya University, Nagoya, Japan

14. <u>Break-of-Symmetry Radiation with Ions.</u>* J. N. LEBOEUF, T. TAJIMA, J. M. DAWSON, <u>UCLA</u>.--One-and-two-halves dimensional relativistic electromagnetic particle simulations have been carried out to study the beam-plasma instability with ion dynamics. With the wavevector along the guide magnetic field, no radiation is generated without ion dynamics. With ion dynamics, intense radiation is emitted. We attribute this effect to the angular momentum exchange between electrons and ions which breaks a symmetry condition which holds if only electron dynamics are included.

*Work supported by U.S.D.O.E. and N.S.F.

15. <u>Clamping of Runaway Electrons by Radiation</u>* M. THAKER, J. N. LEBOEUF, T. TAJIMA, J. M. DAWSON, <u>UCLA</u>.--In tokamak experiments it has been found that the momentum of runaway electrons can be clamped; under these conditions bursts of radiation are detected. By changing the tilt angle between the wavevector and the DC E-field and B-field direction in a 1-2/2 D relativistic electromagnetic particle code, we study the character of the wave-particle interactions. Through the runaway electrons, the DC E-field significantly enhances Langmuir wave activity and also produces radiation when the tilt angle is non-zero. These modes interact directly with the runaways and substantially retard them; sometimes completely halting their acceleration. When the electromagnetic interaction is not included we never observe complete clamping of the runaways. Furthermore, inclusion of ion dynamics enhances these processes. These effects which lead to enhanced radiation may have applications in traveling wave tubes and free electron lasers.

*Work supported by U.S.D.O.E.

16. Relativistic Electron Ring Experiments in Macrotor* Z. LUCKY, S. TALMADGE, R. J. TAYLOR, and S. J. ZWEBEN, UCLA and M. YAMADA, Princeton University,--Macrotor has been operated in the relativistic beam mode in which the current and energy content of the plasma are contained in a high energy internal ring. Unlike previous experiments these rings can be created under low impurity conditions, and can be maintained in the absence of a background plasma (e.g., we have had 50 kA rings lasting for 100 msec at $n_e \approx 10^{10}$ cm^{-3}). Cyclotron radiation from the beam is increased by a factor of ~ 40 over thermal level. The ring is, in some cases, observed to make a single step-wise transition to a low current (~ 5 kA) equilibrium state which lasts as long as 50 msec and is characterized by a change in the cyclotron radiation from very noisy to quiescent, but with small change in mean value. This equilibrium state apparently satisfies the betatron condition in vertical field. The cyclotron emission spectrum is consistent with that of a betatron with a critical frequency of 50 GHz.

* Supported by USDOE Contract EY-76-C-03-0010 PA 26

17. Ion-Acceleration Via Time Phased Resonant Absorption.* G. SCHLEGEL, J. M. DAWSON, G. J. MORALES, A. WONG, UCLA.--Ions in an inhomogeneous plasma can be accelerated by the ambipolar potential associated with the ponderomotive force developed during resonant absorption. This acceleration can increase the ion energy by a few kT_e. It has been suggested by A. Wong[1], that continuous acceleration of the ions can be obtained by changing the frequency of the external pump to time phase the resonant absorption region with ion motion. This phenomena has been investigated by a 1½ dimensional, electrostatic particle simulation code. Using a linear density gradient and a background of heavy ions, a beam of light ions has been accelerated to energies of greater than 10 kT_e by changing the frequency of a capacitive pump field. This increase in ion energy is linear with the number of resonant spikes created. Such acceleration may also occur for a constant pump frequency but with the plasma density increasing with time.

A. Y. Wong, "Cavitons", Journal de Physique, C6-12, Dec. 1977.

*Work supported by U.S.D.O.E. and N.S.F.

18. Generation of $2\omega_{pe}$ Radiation in a Turbulent Plasma*, J. Santoru, P. Leung and A. Y. Wong, UCLA.--Experiments investigating the generation of $2\omega_{pe}$ radiation are performed in a large vacuum chamber (2 m in diameter and 2 m in length). Counterstreaming electron beams are injected into the background plasma to excite electron plasma waves. The level of the electron plasma wave turbulence can be varied by adjusting the beam voltages and beam densities. The radiation at $2\omega_{pe}$ is detected by a microwave horn. Comparisons of the power spectrums of the $2\omega_{pe}$ radiation and the electron plasma wave turbulence are presented.

*Supported by NSF PHY77-07160.

19. Measurement of Anomalous Penetration of RF Fields in a Collisionless Plasma.* H. GOEDE, J. M. DAWSON, K. R. MAC KENZIE, UCLA.--At RF frequencies $\omega << \omega_{pe}$, enhanced penetration of fields beyond $\delta_c = c/\omega_{pe}$ occurs when $v_{te} \approx \delta_c \omega$. This anomalous skin effect can have considerable influence in the heating of plasmas in thermonuclear devices by RF and the launching of waves by antennae embedded in the plasma. To demonstrate the effect we propagate a low power wave along a coaxial line. An unmagnetized, uniform plasma produced by a dc discharge in a vessel of .9 m diameter and 1.7 m in length fills the space between the central conductor and the radial chamber wall. Measurements of the radial spatial decay of the oscillating magnetic field enable one to extract values of the skin depth. In the classical regime penetration depths in the range $1.6 < \delta < 10.$ cm could be measured with good correspondence to values of δ_c obtained from Langmuir probes. For fixed density and temperature, field penetration is observed to remain constant until ω is low enough for thermal effects to be important; at this point skin depths increase approximately as $\omega^{-1/3}$.

*Work supported by U.S.D.O.E.

20. Particle Simulation of Reconnection Dynamics* T. TAJIMA, J. N. LEBOEUF, J. M. DAWSON, UCLA.--Particle simulations of magnetic x-point dynamics have been carried out on a 2-1/2 D magnetostatic code. The external sheet currents are applied with time dependence. Without the toroidal magnetic field, the stability of the x-point is determined mainly by the geometry of the sheet currents. The number of islands seems to be proportional to the length of the sheet. When it is stable, the process is primarily electrostatic and heating is due to shocks; when unstable, the process is magnetic.

*Work supported by U.S.D.O.E. and N.S.F.

21. Dodecapole Surmac*, R. W. Schumacher, M. Fukao, A. Y. Wong, K. Yatsu, M. Huffer, K. L. Lam, J. Levy, UCLA,--The Dodecapole Surmac is a six hoop toroidal multipole with major radius 45 cm, minor radius 20 cm, hoop sum current $\leq$ 575 kA, and peak bridge field ~ 6.4 kG which is designed to study transport scaling and MHD stability at finite β in high energy density multipole plasmas. Plasma parameters in equilibrium following coaxial gun injection are $n = 10^{12}$ cm^{-3} and T_i ~ 220 eV to $n = 1 - 2 \times 10^{13}$ cm^{-3} and T_i ~ 100 eV with peak bridge $\beta = 0.1$ to 1.0% in low density collisionless discharges. In the high density collisional regime $n \sim 8 \times 10^{13}$ cm^{-3} and T_i ~ 20 eV with β ~ 2.8%. T_e is 12 - 20 eV in both regimes. Paramagnetic $\delta B/B$ ~ 1% is observed at the surface of the nearly flux conserving vacuum wall when separatrix β ~ 2%. Both T_i and τ_E (~100 - 400 μs) are limited by charge exchange and other atomic processes resulting from the recycling of untrapped plasma on the vacuum chamber walls. High power neutral beam heating systems (300 kW, power density 1W/cm) and an upgraded magnetic field system ($\Sigma I_H = 1.35$ MA, bridge field ~ 15 kG) under development are aimed toward achieving neutral burn out and sustained Dodecapole plasmas with T_i ~ 500 eV and $\tau_E > 1$ ms.

*Supported by USDOE EY 76-C-03-0010 PA 26.

22. Multipole Scaling With Order* J. Levy, R. W. Schumacher, M. Fukao, A. Y. Wong, UCLA.--The question of optimum multipole order is currently a rather controversial topic in multipole research. To quantitatively evaluate multipole parameter scaling with order, seven linear multipoles having order from quadrupole to eikositetrapole (m = 2, 3, 4, 6, 8, 10, 12 conductors) were studied using a vacuum magnetic field code. In comparing each order, the radius of the configuration and the amount of stable common flux were held constant. Using simple scaling laws and parameters which are easily gleaned from vacuum field topology, it was found that all the desirable physics parameters of multipole confinement improve as the order is increased. These include number of confined particles, confinement time, magnetic well depth, connection length, critical peak bridge beta, and ratio of unmagnetized to total plasma particles. However, the engineering features of multipoles become less desirable as the order is increased. Not only are there more rods to support or levitate at high order, but the confinement region collapses toward the conductors, conductor minor radii decrease, and total current, current density, and power dissipation (for normal conductors) all increase as the order scales up.

* Supported by USDOE EY 76-C-03-0010 PA 26.

23. Equilibrium and Stability of High-β Toroidal Multipoles.* D. A. D'IPPOLITO, E. A. ADLER, Y. C. LEE, UCLA.--The equilibrium and stability of finite-β toroidal plasmas confined by multipole fields (with no toroidal component) is studied within the framework of ideal magnetohydrodynamics. Equilibria are obtained by the numerical solution of the Grad-Shafranov equation, including the effect of rigid current-carrying rings within the plasma. Stability to pressure-driven modes (interchange and ballooning) is examined for these equilibria using the method of Johnson et al. The spatial variation of the critical pressure gradient and the nature of the marginally-stable eigenfunctions are discussed. Results are presented for three configurations (quadrupole, octopole, and dodecapole) with parameters similar to those for the UCLA Surmac experiment.

*Supported by U.S.D.O.E. and N.S.F.

24. Particle Simulation of Current Sheath Dynamics.* G. SCHLEGEL, J. M. DAWSON, UCLA.--A $2\frac{1}{2}$ D magnetostatic particle code suitable for investigating magnetic sheaths associated with external drive currents has been developed. The code can be used to study TORMAC sheaths where particles are lost from the sheath region or other configurations where magnetic sheaths are involved. Preliminary results show that both the collisionless skin depth ($\delta = c/\omega_p$) and finite ion Larmor radii are important. In addition to the sheath dynamics, bulk plasma oscillations have been observed driven by the currents. These oscillations have a period of L/V_A where L is the plasma thickness and V_A is the Alfven Velocity. We are planning to look for sheath instabilities.

*Work supported by U.S.D.O.E.

25. Electrostatic Confinement in Macrotor,* LENA OREN, S. TALMADGE, R. J. TAYLOR, D. WHELAN and S. J. ZWEBEN, UCLA --Negative potential is applied to the inner magnetic surfaces of Macrotor by injecting electrons (10~100A) from biased W filaments. The radial electric field is localized on the outer magnetic surfaces of the plasma in an annulus of width $\Delta r \gtrsim 10\rho_i$ (2 cm). Poloidal rotation of 2×10^6 cm/sec has been measured. The overall hydrogen particle containment time as measured by n_e/H_β light improves by a factor of 10 or more with the application of -300 volt bias. Heavy ions are trapped, as determined from radiation from high ionization states of atoms. The magnetic surfaces assume a constant potential in these experiments. This fact is used to measure the location and shape of the outer magnetic surfaces. Only nearly circular plasmas have been investigated to date. The transverse resistivity is classical and exceeds the parallel resistivity by 10^{10}.

26. Stability Analysis of a Hot Electron (EBT) Plasma.* J. W. VAN DAM and Y. C. LEE, UCLA.--In this analysis, the hot electron annuli are not treated as rigid, noninteracting current rings,[1] but are allowed to be perturbed along with the bulk plasma. An interesting consequence is that the destabilizing effect of field line curvature and finite pressure gradient is found to be unchanged by the presence of the hot electron component, due to detailed pressure balance. However, the plasma compression is greatly enhanced. For marginally stable interchange modes, these two effects balance each other; the threshold annular beta so estimated is about 15%. Ballooning modes will also be discussed.

*Work supported by U.S.D.O.E.

[1]D. B. Nelson and C. L. Hedrick, Nucl. Fusion 19, 283 (1979).

27. Plasma Confinement in an Axisymmetric, High Ratio Magnetic Mirror.* J. R. Ferron, G. Dimonte, P. Young, and A. Y. Wong, UCLA.--MHD stabilization of a mirror confined plasma has been achieved in an axisymmetric, average minimum $|B|$ configuration. This configuration is produced by adding a strong axisymmetric surface field to the field of a simple mirror. This enables the relatively easy construction of a mirror with a large plasma diameter ($R_p/\rho_{ci} \approx 20$) and a high, easily variable mirror ratio ($2.5 < R < 50$). The dependence of confinement time and radial fluctuation profiles on the surface field strength confirms the stabilizing influence of the surface field. Plasma is injected axially from a washer stack gun. The scaling of the plasma and confinement parameters ($T_i \leq 70$ eV, $T_e \leq 10$ eV, $n \leq 5 \times 10^{10}$ cm^{-5}, $\tau < 2$ msec) with field strength and mirror ratio is described. Results from our study of nonadiabaticity in this axisymmetric, high mirror ratio configuration are presented.

*Supported by USDOE contract EY 76-C-03-0010.

28. End-loss from a Long High-β Column: Simulation and Theory.* F. BRUNEL†, T. TAJIMA, J. N. LEBOEUF, J. M. DAWSON, UCLA.--Simulations of the end-loss from a long high-β plasma column in radial pressure equilibrium have been performed in a slab geometry with a 2-½ D particle MHD code. At t equal zero the plasma has a sharp boundary, and the end losses are treated by taking lost particles out of the system. Contrary to the previous sharp boundary theories, the end-loss time does not scale like $(1-\beta)^{1/2}$ for large β, but is only a slowly increasing function of β: this is close to Brackbill's simulations and other experiments. The area MHD waves are found to have the dispersion relation $\omega/k_{\parallel}=c_s[1-(\beta/2)/(1+k_{\parallel}a-\beta/2)]^{1/2}$, where a is the column radius. The physical origin of the non-zero phase velocity at $\beta=1$ comes from the curvature effect (tension) of the magnetic field lines in the perpendicular force balance equation: this term tends to throw the plasma out and gives the wave a finite propagation speed at $\beta=1$. When mirrors are applied at the ends of the plasma column, substantial reduction in the end-loss is observed.

*Work supported by U.S.D.O.E. and N.S.F.
†Supported by DGES Fellowship.

29. Neutral Beam Heating in the Dodecapole Surmac* K. Yatsu, R. W. Schumacher, A. Y. Wong, H. M. Lai, G. Hockney, UCLA.--In the Dodecapole Surmac device T_i and τ_E in high density gun injected plasmas ($T_i \sim 100$ eV, $T_e \sim 15$ eV, $n \sim 2 \times 10^{13}$ cm^{-3}, $\tau_E \sim 100$ μs) are limited by charge exchange and other atomic processes. High power neutral beam heating (300 kw, power density ~1 w/cm^3) systems are being developed (see W. Williamson et al., this meeting) for burning through the atomic phenomena barrier and sustaining the Dodecapole plasma at $T_i \leq 500$ eV and $\tau_E > 1$ ms. The first step in this program is a 2 keV 6 A test injection system which has been constructed to study the trapping and confinement of 2 keV beam ions. The ion source is a MacKenzie bucket type multi-filament dc discharge with line cusp surface field. The ion beam is extracted from an 8 cm x 8 cm three grid system with 4037, 0.99 mm diameter circular aperatures. The accel and decel grids are spaced 1.5 mm apart. With a target depth of 50 cm, 80% of the beam is expected to be depostied in the plasma. Due to the high beam energy to T_e ratio ~ 100, most of the energy goes to the electrons. A detectable 5 eV increase of the electron temperature is anticipated. Results of a heating rate zero dimensional code are also presented.

* Supported by USDOE EY 76-C-03-0010 PA 26.

30. Burn-out and Plasma Heating by Neutral Beams* H. M. Lai†, A. Y. Wong and G. M. Hockney, UCLA.--A multi-group model for the heating of a target plasma by neutral beam injection and for the burn-out of cold neutrals is presented. The plasma is assumed in a closed line magnetic trap. Rapid build-up of a hot dense plasma occurs if $\tau_b < \tau_s$ and $\tau_b < \tau_x$, where τ_b is the build-up time for the hot ions due to charge-exchange with the beam neutrals, τ_s is the slowing-down time due to the bulk plasma and τ_x is the loss time due to charge-exchange with the cold neutrals. Electron temperature stagnation or decrease is also shown if enough impurities are present. Requirements to achieve a real burn-out of the troublesome cold neutrals will also be given and discussed, together with computer plot-outs.

* Research supported by USDOE contract EY 76-C-03-0010 PA26.

† On sabbatical from the Deaprtment of Physics, The Chinese University of Hong Kong.

31. Deflagration Gun Injection and Heating In The Dodecapole Surmac*, M. Fukao, R. W. Schumacher, A. Y. Wong, K. Yatsu, UCLA, P. P. Tripathi, D. Y. Chang, Univ. Santa Clara.-- A LASL type Marshall gun has been modified to operate in the deflagration mode on the Dodecapole Surmac. Experiments on gun injection into the vacuum Dodecapole field are consistent with deflagration gun theory. The plasma stream is well collimated with single component, cold ions at high streaming energy ~ 700 eV, and the lower electrode current density compared to the Marshall mode leads to much colder electrons ~4 eV and lower impurity generation. Due to effective collimation, application of plasma guide field across the drift chamber increased the trapped plasma density only ~20% compared to 800% for the Marshall mode. Non-thermalized deflagration plasma of density 2×10^{13} cm^{-3} and mean energy ~ 700 eV was trapped in the Dodecapole for ~ 30 transit times to the wall but an equilibrium was not achieved due to insufficient stable multipole flux. The deflagration plasma has also been injected into a target plasma of $n = 1 - 4 \times 10^{13}$ cm^{-3}. Penetration and trapping of the additional plasma stream is unaffected by the presence of target plasma. Preliminary data on deflagration gun heating indicates a charge exchange measured T_i ~ 150-200 eV at $n = 2 - 4 \times 10^{13}$ cm^{-3}.

*Supported by USDOE EY 76-C-03-0010 PA 26.

32. <u>Resonance Surfaces and High Wave-Number Modes in RF Plasma Heating</u>.* E. CANOBBIO, <u>UCLA</u> and <u>ASSOCIATION EURATOM-CEA GRENOBLE</u>.--RF power is mainly absorbed in the neighborhood of the wave resonance surfaces which, in a magnetized plasma, occur in four different frequency ranges. Unfortunately such surfaces may cross the periphery of the confined plasma. In addition, if sufficiently high wave-numbers are excited, resonance cones, surface waves and caustics (e.g., "Whispering Gallery" and "Bouncing Ball" modes) may substantially enhance the field amplitude at the plasma surface. We briefly review these matters in relation to the problem of RF heating, with particular emphasis on the characteristics of wave propagation below the ion gyrofrequency in a finite-beta plasma. Finally, we present an intuitive formulation of the physics involved in heating at very low frequencies.

*Partially supported by U.S.D.O.E.

33. <u>ICRF Heating in Macrotor</u>,* R. J. TAYLOR and G.J. MORALES, <u>UCLA</u> -- We have been experimenting with ICRF heating at low magnetic fields (2 kG) and high power levels (0.5 MW). During this time we have achieved impurity control ($n_{ox} < 3 \times 10^9$ cm^{-3}) and solved the power input technology problems in Macrotor. In earlier experiments the heating was found to be limited by pump-out. The particle and energy containment times diminished with increasing power to 1 msec. Recently, by the application of negative bias to the inner magnetic surfaces the induced density loss was reduced. Substantial improvement of the heating was obtained ($\Delta T_i \sim 200$ eV, $\Delta T_i/T_i \sim 5$). The charged particle containment time is ~ 30 msec at densities near 5×10^{12} cm^{-3}. This is an order of magnitude improvement over the Alcator scaling. As in many other experiments, the electron channel behavior is not yet clear. Ion transport is slightly enhanced at toroidal resonances.

* Supported by USDOE EY-76-C-03-0010 PA 26

34. Charge Exchange Measurements on Macrotor During ICRF Heating, * D. A. WHELAN, and R. J. TAYLOR, UCLA-- Perpendicular charge exchange measurements were made on the Macrotor tokamak in the presence of second harmonic ICRF heating. Input power levels of three times OH in a D_2/H_2 (95/5%) plasma have yielded ion temperatures of 120-140 eV, ($\Delta T_i/T_i \simeq 3$). The heating was accompanied by a high energy tail ($T_T \simeq 350 \rightarrow 400$ eV). Measurements were also made in the presence of a negative plasma potential which showed dramatic increases in T_i, i. e., under similar conditions as above, charge exchange showed $T_i \approx 220$ eV, ($\Delta T_i/T \simeq 5$).

* Supported by USDOE Contract EY-76-C-03-0010 PA 26

35. Electron Temperature Measurements on Macrotor with ICRF Heating* S. TALMADGE, UCLA --Use of a chromium doped ruby filter has completely eliminated stray light problems so that Thomson scattering can be performed at densities as low as 2×10^{12} cm^{-3} on Macrotor. Measurements indicate an ohmically heated central temperature of 90 eV. Application of second harmonic ICRF power in a deuterium plasma with substantial hydrogen minority at a level of three times ohmic power has increased Te to 250 eV with a concomitant rise in plasma current. Variations in harmonic number and fill gas have also increased Te to varying degrees. Temporal behavior of Te shows a rapid rise followed by an immediate decay (in ~ 2-3 msec) to the pre-heated value. This is a result of the density "pump-out" which accompanies the introduction of RF power which in turn reduces the antenna loading. Recent application of an electrostatic potential well has halted the density drop. However, no significant increase in electron temperature has been measured as of yet. Spatial profiles will be presented.

* Supported by USDOE Contract EY-76-C-03-0010 PA 26

36. Effect of ICRF Heating on Single Particle Confinement in Tokamaks.* K. WHANG, G. J. MORALES, UCLA.--The resonant interaction between a fast Alfven wave of frequency ω and ions of gyrofrequency Ω is formulated in terms of finite difference jumps in the magnetic moment $\Delta\mu$ at those points where $\omega = n\Omega$, $n = 1,2$. The μ dependence of the jump is retained as well as the full elliptic integral expression for the phase changes between jumps, thus permitting the study of the continuous transitions between passing and trapped particles which occur in the tokamak geometry due to RF heating. A numerical study of the phase space topology shows that stochastic behavior sets in at experimentally small wave amplitudes. The ensuing spatial diffusion is investigated. The effect of the wave magnetic field on the electrons is also considered.

*Work supported by U.S.D.O.E. and O.N.R.

37. Computer Simulation of RF Heating with Lower Hybrid Waves.* V. K. DECYK, G. J. MORALES, J. M. DAWSON, UCLA.--A bounded electrostatic particle simulation code is used to study the problem of RF heating with lower hybrid (LH) waves. The initial plasma density increases away from the exciter (located on one boundary) with $\nabla n \perp \vec{B}_o$, and the frequency ω_o has been chosen so that both a propagation region and a turning point for LH waves exists inside the plasma. For high ion temperature ($T_e/T_i \sim 1$), LH waves are directly absorbed by the ions before the wave conversion layer is reached in the plasma interior, in contrast to earlier results with cold ions ($T_e/T_i = 10$).[1] Studies of the nonlinear orbits of particles in the sheath region near the antenna are presented for various antenna structures. Results on the generation of DC current by a high phase velocity ($\omega/k_\parallel = 4.1\ v_{th}$) traveling wave are also presented.

[1]V. K. Decyk, G. J. Morales, and J. M. Dawson, UCLA Center for Plasma Physics and Fusion Engineering Report PPG-411 (1979).

*Work supported by U.S.D.O.E. and O.N.R.

38. Thomson Scattering System for the Dodecapole Surmac*. K. Jones, R. W. Schumacher, A. Y. Wong, UCLA, R. F. Weurker, TRW.--Neutral beam heating experiments in the Dodecapole Surmac will require optical probing of plasma electron parameters. A 90° Thomson scattering system is being developed to measure electron heating over the temperature range 15 eV → 200 eV for plasma densities $n_e \sim 1 - 5 \times 10^{13}\ cm^{-3}$. The present coaxial gun injected (unheated) plasma with parameters $n_e \sim 8 \times 10^{13}\ cm^{-3}$ and $T_e \sim 20$ eV is expected to scatter enough photons from an incident 3J, 50 nsec Q-switched ruby laser beam into a 2×10^{-2} sr. viewing angle to yield 8 μA/10 Å BW of photomultiplier output signal at the 6943 Å line center. Optical coupling of light dispersed by Fastie-Ebert (f-5) grating polychromator to 8 high quantum efficiency photomultiplier (RCA #31034A) channels (integrated with Dodecapole data acquisition system) will be detailed. Special mechanical limitations inherent in the Dodecapole geometry make systematic reduction of stray primary laser light a critical factor in the design of input and light collection optics.

*Supported by USDOE EY 76-C-03-0010 PA 26.

39. Diagnostics and Computer Based Data Acquisition System for the Dodecapole Surmac*, M. E. Huffer, R. W. Schumacher, R. Bollens, A. Y. Wong, J. Ferron and H. Ko, UCLA.--A microprocessor based data acquisition system has been constructed and interfaced to the Dodecapole Surmac. Diagnostics include a 10 channel polychromator, single channel monochromator, Thomson scattering, charge exchange neutral ion energy analyzer, 2 and 4 mm μ wave interferometers, gridded electrostatic ion energy analyzer, $\dot{B}$ and Hall magnetic probes, and Langmuir probes. Each diagnostic is interfaced to the data system by line drivers through 10 M cables to analog conditioners which tailor the signals to the ADC's. The data system is Camac standard with 16 independent channels of data acquisition triggered by the experiment master timer. Each channel is an 8 bit digitizer with a Kbyte of buffer space. Sample rates are selected independently under program control at up to 1 MHz. The system is controlled by an LSI-11 microprocessor which is housed within the Camac crate. Twin 256 Kbyte floppy disks provide long term data storage. The processor also performs real-time data analysis, providing the experimenter with reduced data following each discharge.

*Supported by USDOE EY 76-C-03-0010 PA 26.

40. Improved Vacuum Photodiode UV Detector Arrays for the UCLA Tokamaks, S. J. ZWEBEN and R. J. TAYLOR, UCLA*-- Filtered vacuum photodiodes have been used on Macrotor to find spacial radiation profiles in the bands $\lambda \approx 200\text{-}1200$ Å (bare detector)†, $\lambda \approx 200\text{-}700$ Å (1500 Å thick Al/Si filter), and $\lambda \approx 200$ Å (8000 Å thick polypropelene filter). The bare detectors are sensitive mainly to soft UV from hydrogen in ultra clean Macrotor discharges, while the Al/Si filtered detectors respond to residual low-Z impurities. Radiation profiles are generally more peaked toward shorter wavelengths. Results from a 12 detector array on Microtor will be presented.

* Supported by USDOE Contract EY-76-C-03-0010 PA 26

† S. J. Zweben, C. R. Menyuk, and R. J. Taylor, Rev. Sci. Instr. (to be published)

41. Nonlinear Saturation and Thermal Effects On The Free Electron Laser Using An Electromagnetic Pump.* C. C. LIN, A. T. LIN, J. M. DAWSON, UCLA.--The production of visible laser radiation by low energy relativistic electron beams (MeV) is most readily accomplished through the use of a high frequency (far infared) electromagnetic pump ($\lambda_\gamma = \lambda_p/4\gamma_0^2$); such radiation can be generated by reflecting the radiation it generates by interacting with a rippled static magnetic field. It is important to investigate what limits the efficiency in this situation. We found that with a weak pump field, the pump energy can be amplified by a factor of $4\gamma_0^2$ and the pump intensity by $16\gamma_0^4$ with the instability being terminated by pump depletion. With a strong pump field particle trapping in the plasma wave generated on the beam stops the growth of the instability and the initial momentum spread (temperature) limits the saturation amplitude.

*Work supported by U.S.D.O.E. and N.S.F.

42. Finite-Length Particle Simulations of a Free Electron Laser.* P. C. LIEWER, A. T. LIN, M. ZALES CAPONI†, J. M. DAWSON, UCLA.--In the free-electron laser, a relativistic electron beam passes through a static rippled magnetic field. The ripple field couples the plasma beam modes and the electromagnetic modes and causes an instability which leads to coherent electromagnetic radiation. Past particle simulations have treated the system as an infinite homogenous periodic system.[1,2] 1-D finite length simulations have now been performed. It is found that it is possible for different modes to dominate than in the infinite periodic system. In the infinite system, where the instability is absolute, the mode with the fastest growth rate dominates. In the finite system, modes with lower growth rates but shorter growth lengths (low group velocities) can dominate. Results are compared to theoretical predictions for infinite systems.

[1]A. T. Lin, J. M. Dawson, and H. Okuda, Phys. Fluids 17 1995 (1975).
[2]T. Kwan, J. M. Dawson and A. T. Lin, Phys. Fluids 20 581 (1977).
†TRW Systems
*Work supported by N.S.F. and U.S.D.O.E.

43. Active Stimulation of the Auroral Plasma.* A. Y. Wong and J. Santoru, UCLA.--Experiments to actively stimulate the auroral plasma are described. The auroral region is particularly interesting for several reasons: 1). Particle beams (which can provide energy for the growth of certain plasma modes) are present. 2). The magnetic field geometry allows propagation of the HF radio waves at various angles (from parallel to perpendicular) with respect to the magnetic field. The basic technique is to use a ground-based pulsed HF radio wave system to deliver very high power densities to the auroral ionosphere. The frequency of the HF radio waves would match the local plasma resonance in the E or F layers. Using this technique it may be possible to locally excite and quantitatively study short-term nonlinear phenomena such as resonant enhancement, density profile modification, particle energization and the modification of the auroral optical emission.

* Work supported by ONR contract N00014-78-C-0754.

44. Linear Theory of Tearing in a High-β_e Plasma*

K. B. QUEST, F. V. CORONITI, UCLA.-- We calculate the linear tearing dispersion relation for a collisionless plasma in a sheared magnetic geometry, and extend the existing results to include intermediate to high β_e (ratio of electron thermal pressure to magnetic pressure) plasmas, and T_i and T_e (ion and electron temperature, respectively) such that $T_i >> T_e$. We find that in the absence of electrostatic effects, the dispersion relation for arbitrary β_e is the same as found previously (Laval et al., 1966; Drake and Lee, 1977) for the small β_e limit. If $\beta_e << 1$ and $T_i >> T_e$, the growth rate is enhanced by a factor $\sim\sqrt{T_i/T_e}$, while if $\beta_e \gtrsim 1$, electrostatic effects are unimportant, and the gorwth rate is unaltered for arbitrary T_i/T_e. Applications to magnetospheric physics are discussed.

*Work supported by N.A.S.A. and N.S.F.

45. Global Simulation of the Magnetosphere in Three-Dimensions.* C. F. KENNEL, J. N. LEBOEUF, T. TAJIMA, J. M. DAWSON, UCLA.--A particle MHD code is used to simulate the earth's magnetosphere in a nonlinear, time-dependent, dissipative and three-dimensional set-up. The solar wind is along the x-direction and the southward interplanetary magnetic field along y. With current rods extended all along z to model the earth's magnetic field, the Dungey reconnection pattern previously obtained in 2-1/2 D[1] is recovered. For a loop current in the x-z plane at the mid-point in y, this pattern prevails in the plane of the dipole centers.

[1]J. N. Leboeuf, T. Tajima, C. F. Kennel, J. M. Dawson, Geophys. Res. Lett. 5, 609 (1978).

*Work supported by N.S.F.

46. Cold Electrons Heating by Magnetospheric Electrostatic Waves.* D. SENTMAN, M. ASHOUR-ABDALLA, J. N. LEBOEUF, J. M. DAWSON, C. F. KENNEL, UCLA.--Electrostatic waves at half integral multiples of the gyrofrequency are believed to play an important role in diffuse auroral precipitation.[1] $2\frac{1}{2}$ D electrostatic particle simulations of a warm ring distribution function for the hot electrons perpendicular to the magnetic field and a Maxwellian background of cold electrons yield unstable wave spectra at half-integral multiples of the gyrofrequency for modes with a small parallel wavevector; without cold electrons, the instability is either nonexistent or very slow. Substantial heating and cross-field diffusion of the cold electrons result from the unstable waves.

[1]M. Ashour-Abdalla and C. F. Kennel, J. Geophys. Res. 83, 1531 (1978).

*Work supported by N.A.S.A. and N.S.F.

47. Experimental Study of In-Situ Wall Coatings in Tokamaks*, E. M. TENESCU, R. J. TAYLOR and Z. LUCKY, UCLA--We have investigated the wall conditions required to obtain very clean (oxygen < $3 \times 10^{9} cm^{-3}$) tokamak plasmas. Metal depositions have been monitored by an array of quartz crystal-oscillators whose frequencies change in accordance with the thickness of the layer deposited on them. The sensitivity of these measurements is about $\Delta f/f \approx 10^{-7}$ corresponding to ~ .5 Å. The influence of metal deposition thickness and wall conditions on the discharge impurity level is examined.

PPG-382 "Stimulated Brillouin Sidescatter and Backscatter of CO_2 Laser Radiation From a Laser-Altered Arc Plasma", Mark J. Herbst, dissertation, January (1979).

PPG-383 "Small-Scale Magnetic Fluctuations inside the Macrotor Tokamak", S. J. Zweben, C. R. Menyuk, and R. J. Taylor. Submitted to Phys. Rev. Lett., January (1979).

PPG-384 "A High Efficiency Free Electron Laser", A. T. Lin and J. M. Dawson. Submitted to Phys. Rev. Lett., January (1979).

PPG-385 "A Parametric Study of Electron Multiharmonic Instabilities in the Magnetosphere", M. Ashour-Abdalla, C. F. Kennel and W. Livesey. Submitted to J. of Geophys. Rev., January (1979).

PPG-386 "Global Formalism for Ballooning-Type Modes in Tokamaks", Y. C. Lee and J. M. VanDam, submitted to Phys. Rev. Lett., October (1978).

PPG-387 "On the Origin of Plasmaspheric Hiss: the Importance of Wave Propagation and the Plasma-Pause", R. M. Thorne, S. R. Church, and D. J. Gorney, submitted to Geophys. Res., January (1979).

PPG-388 "The New Alchemy Again -- Again", F. Chen, accepted by The Sciences, January (1979).

PPG-389 "Stability of Drift-Wave Eigenmodes with Arbitrary Radial Wavelengths", Y. C. Lee, Liu Chen and W. M. Nevins, submitted to Phys. Rev. Lett., February (1979).

PPG-390 "Alternate Concepts in Magnetic Fusion", Frank Chen, to be published in Phys. Today, February (1979).

PPG-391 "Enhanced Interaction between Electrons and Large Amplitude Plasma Waves by a DC Electric Field", J. N. Leboeuf and T. Tajima, accepted by Phys. Fluids, February, (1979).

PPG-392 "Coalescence of Magnetic Islands", P. L. Pritchett and C. C. Wu, submited to Physics of Fluids, February (1979).

PPG-393 "Formation of Double Layers", P. Leung, A. Y. Wong and B. H. Quon. Submitted to Phys. Fluids, February (1979).

PPG-394 "Experiments on Magnetic Field Line Reconnection", R. L. Stenzel and W. Gekelman, submitted to Phys. Rev. Lett., February (1979).

PPG-395 "Magnetospheric Multiharmonic Instabilities", Maha Ashour-Abdalla, C. F. Kennel, and D. D. Sentman, to be published in the Proc. of the Symposium on Wave Instabilities in Space Plasmas, February (1979).

PPG-396 "Comment on the Ballooning Criterion for Multipoles", E. A. Adler and Y. C. Lee, to be submitted to Phys. Fluids, February (1979).

PPG-397 "Laser Electron Accelerator", T. Tajima and J. M. Dawson, submitted to Phys. Rev. Lett., March (1979).

PPG-398 "Pulsar Magnetospheres", C. F. Kennel, F. S. Fujimura, and R. Pellat, to be published in the Proceedings of NASA/JPL workshop on Planetary and Astrophysical Magnetospheres, a special edition of Space Science Reviews, March (1979).

PPG-399 "Nuclear Power as an Ultimate Power Source", F. Chen, March (1979).

PPG-400 "Experimental Observations of Highly Nonlinear States in Plasmas", A. Y. Wong, April (1979).

PPG-401 "The Onset of Stochasticity in a Superadiabatic Mirror," by C. R. Menyuk and Y. C. Lee, April (1979) submitted to Phys. Rev. Lett and Phys. Fluids.

PPG-402 "Linear Stability of High-m Drift-Tearing Modes", D. A. D'Ippolito, Y. C. Lee, and J. F. Drake, March (1979) submitted to Phys. Fluids.

PPG-403 "Aspects of Pulsar Evolution", F. S. Fujimura and C. F. Kennel, March (1979) submitted to Astrophysical Journal.

PPG-404 "A Magnetohydrodynamic Particle Code with Force Free Electrons for Fluid Simulations", T. Tajima, J. N. Leboeuf, and J. M. Dawson, April (1979) submitted to Journal of Computational Physics.

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PPG-406 "RF-Heating of Toroidal Plasmas", E. Canobbio, April (1979), Topics in Applied Physics (Springer-Verlag): Controlled Thermonuclear Fusion - Magnetic Confinement.

PPG-407 "Cross-Field Electron Transport Due to Thermal Electromagnetic Fluctuations", A. T. Lin, J. M. Dawson, and H. Okuda, April (1979), submitted to Phys. Rev. Lett.

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PPG-409 "Confinement of Plasmas by Surface Magnetic Fields (THE SURMAC CONCEPT)", Alfred Y. Wong, May (1979).

PPG-410 "Electron Distribution Functions Associated with Electrostatic Emissions in the Dayside Magnetosphere", D. D. Sentman, L. A. Frank, C. F. Kennel, D. A. Gurnett and W. S. Kurth.

PPG-411 "Simulation of Lower Hybrid Heating in a Nonuniform Plasma Slab", G. J. Morales, J. M. Dawson, and V. K. Decyk, May (1979), submitted to Phys. Fluids.

PPG-412 "Let Us Become Familiar with the UCLA Simulation Codes", T. Tajima, May (1979).

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PPG-414 "Electrostatic and Induced Electric Fields in a Reconnecton Experiment", R. L. Stenzel and W. Gekelman, May (1979 submitted to Jr. Geophys Res.

PPG-415 "Kinetic Theory of Ballooning Instabilities", James W. Van Dam, June (1979) Thesis.

PPG-416 "Diffuse Jovian Aurora Modulated by Volcanic Activity on Io", R. M. Thorne and B. T. Tsurutani, June (1979) submitted to Geophys. Res. Lett.

PPG-417 "Forced Tearing and Reconnection of Magnetic Fields in Plasmas", W. Gekelman and R. L. Stenzel, June (1979), submitted to Phys. Rev. Lett.

PPG-418 "Radiation Protection in Tokamak Fusion Research", J. W. Horner and R. J. Taylor, June (1979).

PPG-419 "Saturation and Reflectivity for the Brillouin Backscattering Instability", T. Tajima, July (1979).

PPG-420 "Theory of Double Resonance Parametric Excitation in Plasmas II", B. D. Fried, A. Adler, and R. Bingham, July (1979), submitted to J. Plas. Phys.

PPG-421 "Study of Low Frequency Microinstabilities in the Microtor Tokamak Using Far Infra Red Laser Scattering", A. Semet A. Mase, W. A. Peebles and N. C. Luhmann, Jr., July (1979).

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PPG-423 "Saturation of Brillouin Back Scatter", M. J. Herbst, C. E. Clayton and F. F. Chen, July (1979), submitted to Phys. Rev. Lett.

PPG-424 "Studies of Back Side Scatter and Back Scatter from Preionized Plasmas", M. J. Herbst, C. E. Clayton, W. A. Peebles, and F. F. Chen, August (1979), submitted to Phys. Fluids.

PPG-425 "Equilibrium and Stability of High-β Toroidal Multipoles", D. A. D'Ippolito, E. A. Adler, and Y. C. Lee, July (1979), submitted to Phys. Fluids.